2. Boiler Feedwater System

2. Boiler Feedwater System

2.1 System Description

The boiler feedwater system consists of deaerator heater, boiler feedwater pumps, intermittent and continuous blowdown system and chemical treatment systems. The boiler feedwater system provides make up water to the boilers. As water in the steam system evaporates or is drained, additional water needs to be added to the system.

Major Equipment Descriptions:

- The deaerator heater is spray-tray type and has a capacity of 190,000 pounds per hour of condensate. The storage tank is sized for 15 minute storage at 190,000 pounds per hour.

- The boiler feedwater pumps (BFPs) are multistage, electric motor driven centrifugal pumps. There are four pumps operating in parallel, serving all the boilers via a common header. Each pump is designed to circulate 130 gpm of water at 435 feet of head.

- The continuous blowdown tank CBT-1 collects the continuous blowdown from all six boilers. The tank has a pneumatic level controller, that opens a control valve to dump excess blowdown when the high level is reached.

- The heat recovery heat exchanger BHX-1 is a shell and tube heat exchanger used for the heat recovery of the blowdown water.

- There are two kinds of chemical treatment systems. Transport Plus and Sure Guard from Nalco are injected into the deaerator. Amines are injected into the feedwater pump discharge header.

2.2 Normal Operating Conditions

Normal Operating Description:

The boilers require feedwater to generate steam. After the initial start-up, the feedwater system operates automatically with the help of DCCS. As the steam is generated in the boilers and distributed to various loads, the water level in the boiler drum drops, and requires feedwater to maintain a minimum water level in the boilers.

Depending on the number of boilers operating, the feedwater pumps are manually turned ON. The pumps operate continuously until they are turned OFF manually. When the water level in the boiler goes down, the automatic control valve in the feedwater line to the respective boiler opens and fills the boiler to a predefined level. When the boilers do not call for feedwater, the 3-way value on the feedwater pump discharge bypasses the

water back to the deaerator.

The feedwater is pre-heated in the economizer before it enters the boiler. In the economizer heat is recovered from the flue gases. Low pressure condensate from condensate tank is pumped into the deaerator tank. All high pressure condensate from the CEP collects directly into the deaerator.

When the water level in the deaerator goes below a set limit, preheated treated water control valve opens to provide make up water. The treated water recovers heat from continuous blowdown water, in the heat exchanger BHX-1. Continuous blowdown from the boilers is collected in the continuous blowdown tank CBT-1.

Intermittent blowdown from the boilers is collected in a flash tank from where it is drained to the intermittent blow off tank IBT-1. The overflow from deaerator and continuous blowdown tank also collect in IBT-1. From this tank the water overflows into the sanitary sewer. The temperature of water in this tank is maintained at 140 degree F by mixing city water.

The chemical treatment consists of two systems. Transport Plus and Sure Guard are injected into deaerator and amines are injected into the feedwater discharge header.

2.3 OMSI Drawings and Photographs

The following OMSI photographs are included for this system:

Figure 1: Deaerator (DA-1) as seen from the CEP mezzanine. The top piece is the deaerating heater.
Figure 2: Typical Boiler Feed Pump (BFP) located under the deaerator.
Figure 3: Blowdown Heat Exchanger (BHX-1)
Figure 4: Continuous Blowdown Tank (CBT-1)
Figure 5: Individual Blowdown Test Station
Figure 6: Boiler Blowdown Testing Station in CEP Mezzanine
Figure 7: 2-Position Motorized Blowdown Control Valve
Figure 8: Blowdown Control Panel

The following OMSI drawings have been developed for this system:

BF-1 Boiler Feedwater System Flow Diagram
BD-1 Continuous Blowdown Flow Diagram

Figure 1: Deaerator (DA-1) as seen from the CEP mezzanine. The top piece is the deaerating heater.

Figure 2: Typical Boiler Feed Pump (BFP) located under the deaerator.

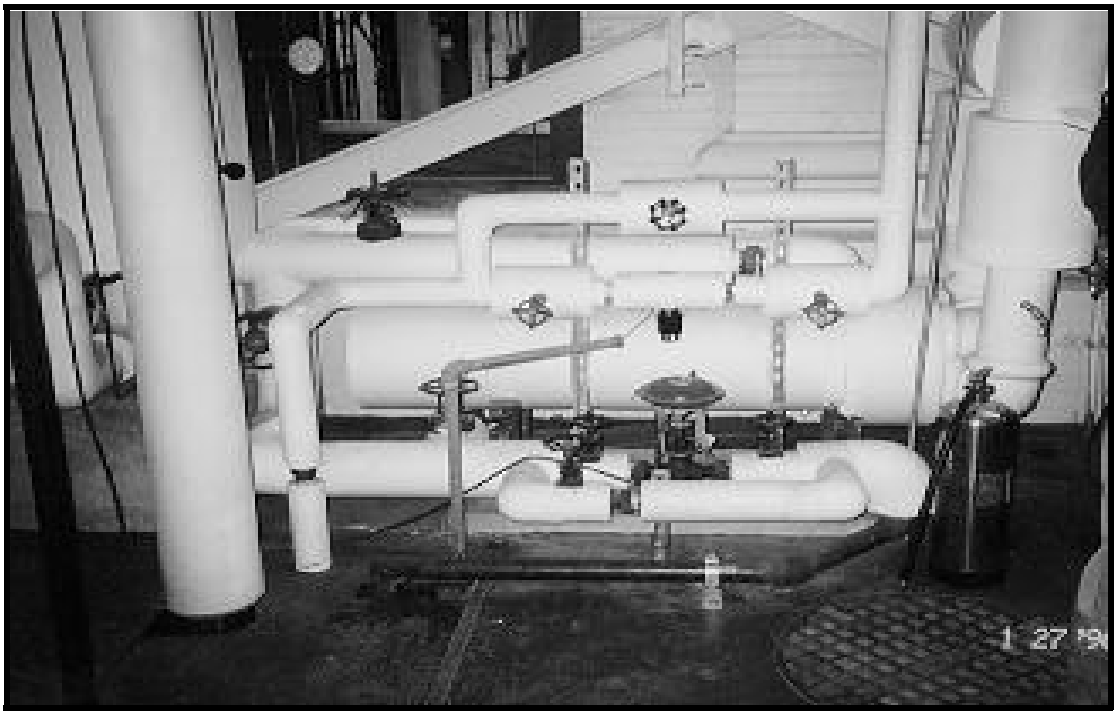

Figure 3: Blowdown Heat Exchanger (BHX-1)

Figure 4: Continuous Blowdown Tank (CBT-1)

Figure 5: Individual Blowdown Test Station

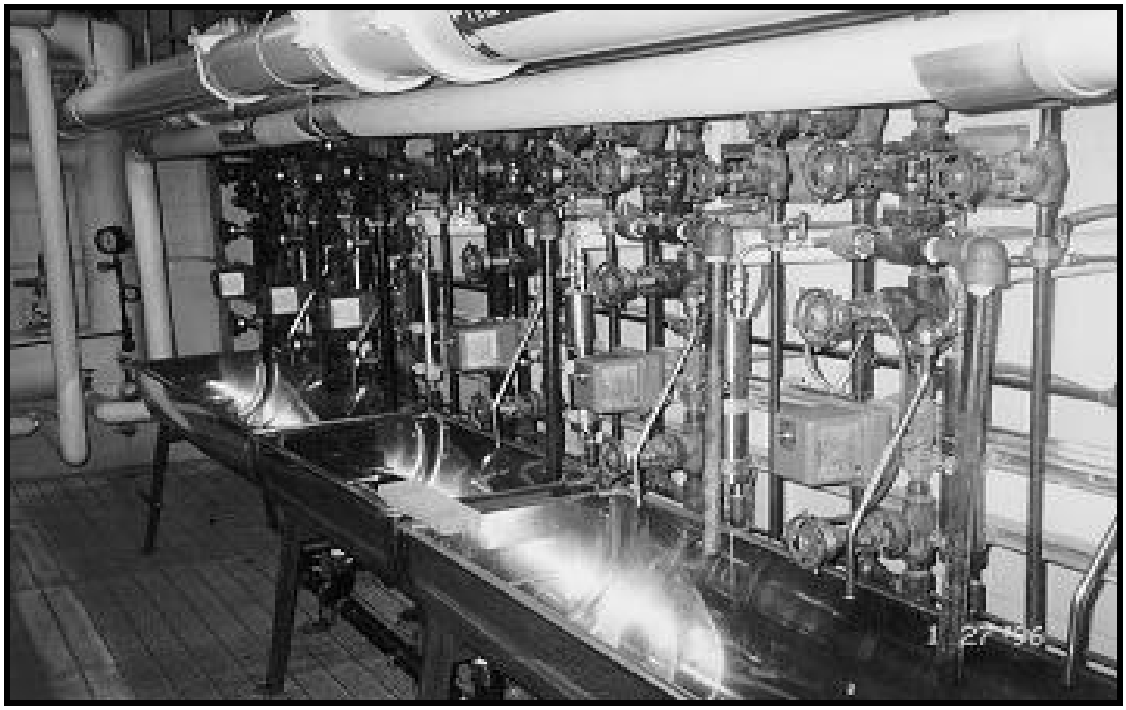

Figure 6: Boiler Blowdown Testing Station on CEP Mezzanine

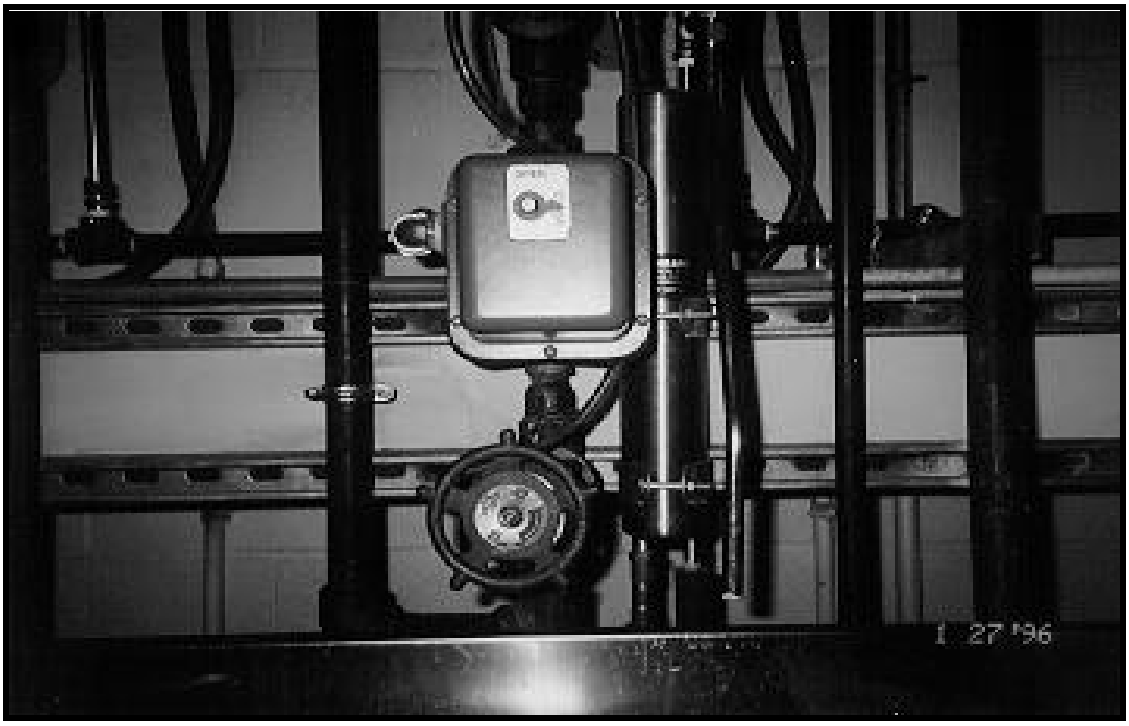

Figure 7: 2-Position Motorized Blowdown Control Valve

Figure 8: Blowdown Control Panel

Figure 9: Intermittent Blowoff Tank (IBT-1)

2.4 System Startup and Shutdown Procedures

2.4.1 System Startup Procedure:

Boiler feedwater pumps are required to be started manually. Depending on the number of boilers on-line, the number of boiler feedwater pumps should be operated. Once the required number of feedwater pumps are started, the feedwater flow to the boilers is regulated by the feedwater controller at each boiler. The excess flow is bypassed through the automatic 3-way flow control valves at the discharge of each pump, and returned to the deaerator.

2.4.2 System Shutdown Procedure:

As the boiler steam demand is reduced and/or one or more of the boilers is shutdown, the feedwater pumps should be manually stopped to match the boiler requirements.

2.5 Emergency Procedures

Many emergency situations are handled automatically by the facility's DCCS. The procedures for this section are included in *Chapter 1: Steam System.*

2.6 Environmental Considerations

The intermittent blowoff tank discharges the blowdown water to the sanitary sewer. Provisions are made to ensure that the temperature of water discharged to the sanitary sewer does not exceed 140^0F. This should be checked regularly.

2.7 Safety Instructions

The following are specific safety instructions for this system. Also refer to the *General Safety Instructions* at the beginning of each binder.

Deaerator

- The deaerator is only part of a large boiler/feedwater system. Persons who come in contact with the system must know all safety rules of the deaerator and connecting and related equipment.
- DO NOT attempt to disassemble, repair, perform maintenance, or otherwise work on a deaerator until all of the potential dangers have been considered and their respective safety precautions followed.

- The deaerator is pressurized during operation and the pressure may remain high after the equipment is shut off. Removal of manway covers, inspection ports, or any bolted connections while pressure exits in the vessel can cause the covers, etc. to break loose or discharge hot, high pressure fluids which could cause injury. Therefore, disassembly or work on the deaerator should not begin until the following precautions have been taken:

  1) Isolate the vessel from the boiler system to insure that there can be no operation, residual, or otherwise of the deaerator.

  2) Check to see that pressure gauges are properly functioning and that the pressure gauges or other pressure indicators show zero pressure.

  3) Carefully open vent valves provided on vessel. Open valves very slowly. Listen for hissing sounds and observe any escaping stream or fluids,. If hissing or escaping fluids are present, do not continue to open until all sounds or fluid discharge stops.

- The deaerator operates at high temperatures that could cause severe burns. When the vessel is shut off, it can take hours or days to cool to safe temperatures. Any temperature in excess of 212 degree F could also indicate the presence of internal pressure. Therefore, disassembly or contact with metal parts should not begin until the following precautions have been taken:

  1) Isolate the vessel from the boiler system to insure that there can be no operation, residual, or otherwise of the deaerator.

  2) Check thermometers or other temperature indicators for proper functioning and assure that temperature is less than 100 degree F.

  3) Use a temperature sensor or comparable devise to determine whether the deaerator has sufficiently cooled.

- Extreme caution should be exercised before entering the deaerator.

  First, deaerator may contain oxygenless gases (e.g. nitrogen) that can cause severe illness or death if inhaled. Deaerator is frequently shipped with nitrogen. Many owners and users of deaerators also pressurize the deaerator with nitrogen during short or long inactivity. Nitrogen is colorless and odorless and cannot be easily detected. Because of the absence of oxygen in gases such as nitrogen, inhalation of sufficient amounts can cause severe illness or death. Therefore, do not enter the deaerator until the precautions listed below have been taken.

  Second, the inside of the deaerator may be very tight and confining. It may also contain sharp corners and protrusions which could cause injury. Any person entering a deaerator should be knowledgeable of the proposed Occupational Safety

and Health Act requirements on confined space entry and should follow the precautions listed below.

The following general precautions must be taken before entering the deaerator:

1) Isolate the vessel from the boiler system to insure that there can be no operation, residual, or otherwise of the deaerator.

2) The work crew should consist of two or more people at all times.

3) Determine that the deaerator contains sufficient oxygen and does not contain any other dangerous gas.

4) Open all vents, manways, or access openings to permit all oxygenless gas to escape and properly ventilate the deaerator. It may be necessary to utilize exhaust fans, ventilators, and blowers to speed the ventilation process. Maintain adequate circulation of oxygen throughout work on the deaerator.

5) Provide adequate scaffolding, platforms, or ladders.

6) Provide adequate lighting.

7) Understand the construction of the equipment and all relevant safety requirements.

8) Use appropriate safety equipment including, but not limited to, hard hats, safety glasses or goggles, gloves, and heavy duty work clothing.

- Safety Valves, Relief Valves, and Other Blow-off Type Equipment (also Vacuum Breaking Equipment)

  All deaerators are protected against damage by one or more safety devices. These devices are designed to discharge in the event that some operating condition causes the deaerator to exceed the standard operating level. This equipment partially relieves the pressure in the vessel and prevents damage.

  The discharge from this equipment is extremely hot and can cause severe injury.

- Various pumps are used with every boiler feedwater system. Injury can occur if proper operation and maintenance procedures are not followed. Therefore, persons performing maintenance on pumps should obtain all instructions, procedures, and safety requirements. Additionally, the following general safety practices should be followed:

  1) Avoid working on the pump while it is operating.

2) If running adjustments are necessary, avoid wearing loose clothing that could become tangled with rotating parts.

3) Always assure that proper electrical disconnections and positive valve lock-outs are used.

4) If the pump must be dismantled, beware of hot fluids and high pressure.

2.8 Valve List

The following valve list will be completed once a valve list is received from the construction contractor:

Valve #	Size	Location	Serves	Type	Normal Position

2.9 Operator Servicing Requirements

The operator servicing requirements are defined as maintenance tasks that need to be performed on a daily basis. Regularly scheduled maintenance tasks that are performed less frequently (e.g., weekly, monthly) are classified as preventive maintenance and are described in sections 2.10 and 2.11.

The following parameters should be observed daily.

Normal Operating Parameters

Blowdown Tank Temperature . . . . . .
Blowdown Tank Pressure . . . . . .
Pneumatic Level Controller Supply Pressure . . . . . .

Pneumatic Level Controller Outlet Pressure . . . . . .
Deaerator Heater Temperature . . . . . 240 °F
Deaerator Heater Pressure . . . . . 10 psig
Boiler Feedwater Pumps Suction Pressure . . . . . .
Boiler Feedwater Pumps Discharge Pressure . . . . . .

2.10 Preventive Maintenance (PM) Plan

Preventive Maintenance for the **Boiler Feedwater System** is composed of two parts. This section is a PM Plan, which for each equipment type in the CEP, provides the PM procedure numbers, and frequencies. The section is arranged by equipment type.

Section 2.11 contains the PM procedures for the CEP equipment. The section is arranged by PM procedure number.

PM Plan: Boiler Feedwater System			
Equipment Description	**Equipment #**	**PM #**	**Frequency**
Deaerator	DAH-1	020001	Annual
Boiler Feed Pumps	BFP-5, 6, 7, 8	020002	Quarterly
Continuous Blowdown Tank	CBT-1	020003	Annual
Intermittent Blow-off Tank	IBT-1	020004	Annual
Blowdown Heat Exchanger	BHX-1	020005	Annual
Chemical Feed System	CFP-7,8,9	020006	Monthly
		020007	Semiannual

2.11 Preventive Maintenance (PM) Procedures

Task #: 020001	Description: Deaerator
Time Required: 16h	**Frequency:** Annual
Skill Level: Boiler Mechanic	
Special Tools:	
Safety Precautions:	

Step 1: Perform a visual examination of all accessible welds and pressure boundaries. Inspect for leaks and or corrosion.

Step 2: Open access covers and inspect the following:
- Spray valves
- Baffles
- Scrubber (spray deaerator)
- Tray stack (tray deaerator)
- Other components that may be cracked broken or worn.

Step 3: Inspect spray valves for the following:
1. Valve must seat firmly
2. Check under plug for debris
3. Valve nuts should be tight with no evidence of leakage under gasket
4. Check valve disks for proper seating. The disks should not appear to hang down if so remove from tank and adjust valve by loosening the top lock nut and hand tighten the spring retainer until the valve disc just seats, then turn one-quarter turn more. Tighten locknut firmly and re-install.

Step 4: The spray nozzle should be checked for foreign matter and that all holes are clean and clear.

Step 5: Check packings of controllers and valves; replace if necessary.

Step 6: Check manhole gasket; replace if there is evidence of leaks or deterioration of the gasket.

Step 7: Check operation of all controllers; they should move freely and not have excessive play. Verify operation of overflow valve and controller, be sure it is not corroded and frozen into closed position. Check operation of storage tank level alarms and deaerator feedwater control.

Step 8: Open and close all gate valves that have not been used since last inspection. Lubricate when necessary.

Step 9: Recalibrate thermometers, pressure gauges and any other instruments.

Step 10: Inspect all piping connections for evidence of corrosion.

Step 11: Inspect insulation.

Step 12: After unit is returned to service, oxygen testing should be performed with more frequency to ascertain that the vent setting is correct.

Step 13: Inspect operation of relief valve by manipulating release lever. The lever should move freely and not have any signs of corrosion.

Step 14: Verify proper condensate inlet water pressure at deaerator.

Step 15: Clean storage tank level site glass if needed. Check operation of valves tighten packing gland if leaking.

Step 16: Bottom blow storage tank.

Task #: 020002	Description: Boiler Feedwater Pumps (BFPs)
Time Required: 3h	**Frequency:** Quarterly
Skill Level: Boiler Mechanic	
Special Tools:	
Safety Precautions:	

Step 1: Report system leaks, defective valves, damaged pipes or fittings.

Step 2: Blowdown y-strainers, clean or replace screen if necessary.

Step 3: Lubricate pump bearings, if applicable.

Step 4: Check shaft seal leakage.

Step 5: Check motor starters, if applicable, for worn, pitted or burned contacts, damaged contactor, armature, burned or scorched coil.

Step 6: Check disconnect switch for pitted, worn or damaged knife blades and clips.

Step 7: Check for air access at the motor ventilation ports.

Step 8: Remove dust and dirt from exterior of motor to allow for heat transfer.

Step 9: Check pump and motor for excessive vibration and high running temperature. When the motor is operating and the pump is loaded, measure and record the current readings in each phase. Record readings in operating log.

Step 10: Check hold-down bolts and grounding straps for tightness.

Step 11: Verify proper operation of the pump and its controls.

Step 12: Open and close all gate valves that have not been used since last inspection. Lubricate when necessary.

Step 13: Verify proper operation of auto flow control valves, at pump discharge and operation of back pressure control valve supplying the deaerator.

Task #: 020003	Description: Continuous Blowdown Tank
Time Required: 2h	**Frequency:** Annual
Skill Level: Boiler Mechanic	
Special Tools:	
Safety Precautions:	

Step 1: Perform a visual examination of all accessible welds and pressure boundaries. Inspect for leaks, rust and or corrosion. Repaint or repair as required. Check mounting brackets and supports for secureness.

Step 2: Inspect operation of relief valve by manipulating release lever. The lever should move freely and not have any signs of corrosion.

Step 3: Check operation of control valve level control to blowdown heat exchanger shell outlet.

Step 4: Inspect temperature and level probes and transmitters for leaks, signs of corrosion and proper calibration.

Step 5: Open and close all gate valves that have not been used since last inspection. Lubricate when necessary.

Task #: 020004	Description: Intermittent Blowoff Tank
Time Required: 2h	**Frequency:** Annual
Skill Level: Boiler Mechanic	
Special Tools:	
Safety Precautions:	

Step 1: Open man-hole access cover and perform a visual examination of all accessible piping, welds and exposed surfaces. Remove any foreign debris that may of collected in drain and tank. Inspect tank for leaks, rust and or corrosion. Repaint or repair as required.

Step 2: Check condition of tempering water control valve sensing element. Verify proper operation of tempering valve.

Step 3: Clean debris from drain screen in tank if required.

Task #: 020005	Description: Blowdown Heat Exchanger
Time Required: 8h	**Frequency:** Annual
Skill Level: Boiler Mechanic	
Special Tools:	
Safety Precautions:	

Step 1: Perform a visual examination of all accessible welds and pressure boundaries. Inspect for leaks, rust and or corrosion. Repaint or repair as required. Check mounting brackets and supports for secureness.

Step 2: Disassemble heat exchanger. Inspect tube sheet and tubes for corrosion and scale. Chemically or mechanically clean as needed. Replace gaskets as required.

Step 3: Check operation of control valve on shell exit line to intermittent blow-off tank. Inspect valve for leaks tighten packing if required.

Step 4: Open and close all gate valves that have not been used since last inspection. Lubricate when necessary.

Task #: 020006	Description: Chemical Treatment System
Time Required: 2h	**Frequency:** Monthly
Skill Level: Boiler Mechanic	
Special Tools:	
Safety Precautions:	

Step 1: Report defective valves at tanks and chemical feed pumps.

Step 2: Report system leaks and damaged pipe or fittings.

Step 3: Report unusual noises or vibrations when either mixer or chemical feedwater pumps are running

Step 4: Check motor surface temperature. Report unusual temperatures.

Step 5: Continuous sample boiler blowdown panel

A. Report defective valves.
B. Check piping for leaks.
C. Check for proper cooling water flow at sampler.

Task #: 020007	Description: Chemical Treatment System
Time Required: 1h	**Frequency:** Semiannual
Skill Level: Boiler Mechanic	
Special Tools:	
Safety Precautions:	
Step 1: Lubricate motor and pump bearings. Step 2: Clean strainers. Report damaged strainers.	

2.12 Corrective Maintenance (Troubleshooting)

#	Problem	Probable Cause and Corrective Action
1	**General**	
	Procedures for the system presented here relate to system functioning only. The following steps should be incorporated into each troubleshooting procedure whenever related equipment has been shut down by an actuated alarm or a system component breakdown. Depending upon the nature of the trouble, take whatever precautions are necessary to safeguard personnel, property and equipment. Determine the most likely causes of the system malfunction and, by the process of elimination, find the actual cause. Correct the faulty condition. A check of corrective measures must be taken to prevent a reoccurrence. Activate the repaired equipment and ascertain that it works properly. Return the system to normal operation.	
2	**Boiler Feedwater Pump does not Run**	**1. No power at motor.**
		A. Check for voltage at motor terminal box. If no voltage at motor, check motor control center for tripped circuits and reset circuits.
		2. Circuit breaker is tripped.
		A. Place circuit breaker at motor control center to ON position. If breaker trips again, the electrical installation, motor and wires must be checked.
		3. Motor starter overloads are burned or have tripped out.

#	Problem	Probable Cause and Corrective Action
		A. Check for voltage on line and load side of starter. Replace burned heaters or reset. Inspect starter for other damage. If heater trips again, check the supply voltage and starter holding coil.
		4. Starter does not energize.
		A. Energize control circuit and check for voltage at the holding coil. If no voltage check control circuit fuses. If voltage, check holding coil for shorts. Replace bad coil.
		5. Defective controls.
		A. Check all safety and pressure switches for operation. Inspect contacts in control devices. Replace worn or defective parts or controls.
		6. Motor is defective.
		A. Turn off power and disconnect wiring. Measure the lead resistances with ohmmeter. Measure lead to ground values with ohmmeter. Record measured values. If an open or grounded winding is found, remove motor and repair or replace.
		7. Pump is bound.
		A. Turn off power and manually rotate pump shaft. If shaft does not rotate easily, check coupling setting and adjust as necessary. If shaft rotation is still tight, remove pump and inspect. Disassemble and repair.
3	**Pump Runs but at Reduced Capacity or does not Deliver Water**	**1. Wrong rotation.**
		A. Check wiring for proper connections. Correct wiring.
		2. Pump is not primed or is airbound.

#	Problem	Probable Cause and Corrective Action
		A. Turn pump off, close isolation valve(s), remove priming plug. Check fluid level. Refill the pump, replace plug and start the pump. Long suction lines must be filled before starting the pump.
		3. Strainers, check or foot valves are clogged.
		A. Remove strainer, screen or valve and inspect. Clean and replace. Reprime pump.
		4. Suction lift too large.
		A. Install compound pressure gauge at the suction side of the pump. Start pump and compare reading to performance data. Reduce suction lift by lowering pump, increase suction line size or removing high friction loss devices.
		5. Suction and/or discharge piping leaks.
		A. Pump runs backwards when turned off. Air in suction pipe. Suction pipe, valves and fittings must be airtight. Repair any leaks and retighten all loose fittings.
		6. Pump worn.
		A. Install pressure gauge, start pump, gradually close the discharge valve and read pressure at shutoff. Convert measured pressure to head. Refer to the specific pump curve for shutoff head for that pump model. If head is close to curve, pump is probably OK. If not, remove pump and inspect.
		7. Pump impeller or guide vane is clogged.
		A. Disassemble and inspect pump passageways. Remove any foreign materials found.

#	Problem	Probable Cause and Corrective Action
4	**Circuit Breakers or Overload Relays Trip**	**1. Low voltage.**
		A. Check voltage at starter panel and motor. If voltage varies more than +/- 10%, contact power company. Check wire sizing
		2. Motor overloads are set too low.
		A. Cycle pump and measure amperage. Increase heater size or adjust trip setting to a maximum of motor nameplate (full load) current.
		3. Three-phase current is imbalanced.
		A. Check current draw on each lead to the motor. Must be within +/-5%. If not, check motor and wiring. Rotating all leads may eliminate this problem.
		4. Motor is shorted or grounded.
		A. Turn off power and disconnect wiring. Measure the lead-to-lead resistance with an ohmmeter. Measure load-to-ground values with an ohmmeter or a megaohm meter. Record values. If an open or grounded winding is found, remove the motor, repair and/or replace.
		5. Wiring or connections are faulty.
		A. Check proper wiring and loose terminals. Replace damaged wire.
		6. Pump is bound.
		A. Turn off power and manually rotate pump shaft. If shaft does not rotate easily, check coupling setting and adjust as necessary. If shaft rotation is still tight, remove pump and inspect. Disassemble and repair.
		7. Motor overloads at higher ambient temperature than motor.

#	Problem	Probable Cause and Corrective Action
		A. Use a thermometer to check the ambient temperature near the overloads and motor. Record these values. If ambient temperature at motor is lower than at overloads, especially where temperature at overloads, especially where temperature at overloads is above 104^0F, ambient-compensated heaters should replace standard heaters.
5	**Insufficient Heating / Excessive Oxygen Content in Deaerator Effluent**	**1. Insufficient venting.**
		A. Increase vent rate by opening the manual operated air vent valve.
		2. Steam pressure reducing valve improper operation or hookup.
		A. Check valve for free operation and make certain that control line is connected to the fitting provided on the deaerator for this purpose and not to the piping downstream of the valve.
		3. Improper spray from nozzle.
		A. Check nozzle for sediment or deposit on seat or broken spring.
		4. Excessive free air due to leaking stuffing boxes on pumps upstream of deaerator which have negative suction head.
		A. Repair stuffing box or seal with water or install free air vent trap in water inlet line to deaerator.
6	**High Water Level / Low Water level in deaerator**	**1. Improper operation of inlet control valve.**
		A. Adjust valve as required.
7	**High Pressure in deaerator**	**1. Faulty reducing valve.**
		A. Check for faulty operation of steam pressure reducing valve.

#	Problem	Probable Cause and Corrective Action
		2. Faulty relief valve.
		B. Check relief valves on deaerator and in the main steam supply system for proper operation.
8	**Low Pressure in deaerator**	**1. Faulty reducing valve.**
		A. Check for improper operation of steam pressure reducing valve.
9	**Excessive Steam Pressure Losses through Deaerator**	**1. Sediment or deposit build-up on trays.**
		A. Check trays for sediment and deposits. Remove and clean if necessary.

2.13 Key Names, Addresses and Telephone Numbers

Lakeside Water Treatment Inc. (Chemical Treatment)
7869 North 73 Street
Milwaukee, WI 53223

Purolite (Ion Exchanger)
150 Monument Rd.
Bala Cynwyd, PA 19004
800-343-1500

Badger Meter (Water Treatment Controller)
Industrial Division
4545 W. Brown Deer Road
P.O. Box 23099
Milwaukee, MI 53223-0099
414-355-0400

Shippensburg Pump Company, Inc. (Boiler Feedwater Pumps)
P.O. Box 337
Shippensburg, PA 17257

Cochrane Environment Systems (Deaerator & Water Cooler)
P.O. Box 60191
King of Prussia, PA 19406
800-633-7435

Pulsa Feeder, Inc. (Treatment Controller)
Electronic Control Operations
2800 South 24 West
Muskogee, OK 74401
918-683-0238